DEPARTMENT OF DEFENCE

DSTO

Guided Weapons Division

GENERAL DOCUMENT
ERL-0817-GD

USER MANUAL FOR STANDARD MISSILE-1, BLOCK VI , MISS-DISTANCE MODEL

by

G.IBAL and S.RETALLICK

ELECTRONICS RESEARCH LABORATORY

DSTO AUSTRALIA

ELECTRONICS RESEARCH LABORATORY

Guided Weapons Division

GENERAL DOCUMENT
ERL-0817-GD

USER MANUAL FOR STANDARD MISSILE-1, BLOCK VI, MISS-DISTANCE MODEL

by

G. IBAL
S. RETALLICK

SUMMARY

A miss-distance model of Standard Missile 1, Block VI, MR, is developed within the MATRIXx/SystemBuild package on a SUN SPARCstation. This document is intended to be a user manual for executing the present mathematical model.

January 1994 COPY No.

APPROVED FOR PUBLIC RELEASE

POSTAL ADDRESS: Director, Electronics Research Laboratory, PO Box 1500, Salisbury, South Australia 5108.

TABLE OF CONTENTS

LIST OF FIGURES

1. INTRODUCTION

This manual is prepared for the users of Standard Missile Miss-Distance Model (SMMDM). The work involved with this document was conducted under NAVY Task NAV 92/365-Standard Missile Modelling.

Detailed technical information about the current model (SMMDM) can be obtained in the technical report listed as reference 1.

2. SIMULATION PROGRAM

The Standard Missile Miss-Distance Model, SMMDM, was developed within the MATRIXx/SystemBuild package on a SUN SPARCstation. As a result, the model as it stands at the moment, can only be run from within the MATRIXx/SystemBuild shell. However, if required, a standalone C code version of the model can be produced.

2.1 Running the model

To run the model you need to first load the MATRIXx/SystemBuild shell. The MATRIXx/SystemBuild shell is licensed software and so can only be loaded on machines which have a MATRIXx/SystemBuild license.

Below is a list of the files required to run the Standard Missile Miss-Distance Model

mwssm6 - MATRIXx/SystemBuild shell
sm1d6 - Standard Missile Miss-Distance Model
runsm6 - MATRIXx execution script
aerotab - aerodynamic tables
missdat - missile data
targdat - target data

To load the MATRIXx/SystemBuild shell, execute the file **mwssm6**. Once the shell has loaded, the user will be faced with the MATRIXx shell prompt (i.e. <>). The Standard missile model can then be loaded with the following command:

```
<> load 'sm1d6'

15 Superblocks loaded.
28 variables loaded from file: sm1d6
```

With the model loaded, the execution script needs to be defined as follows:

```
<> define 'runsm6'

RUNSM6
```

At this stage, the inputs to the model may be modified and the missile model can be executed. Execution of the model is achieved by issuing the command:

```
<> runsm6
```

2.2 Simulation inputs

Below is a brief description of all the input variables. Target related inputs:

X0, Y0, Z0	- Initial target position (metres)
XD0, YD0, ZD0	- Target velocity vector (metres/second)
ATRNTM	- Time target commences turn or weave
GMAX	- Maximum acceleration of target turn or weave
ZWVPR	- Period of target weave

Missile related inputs:

ZRODG	- Missile orientation (0 or 45 degrees)

Other inputs:

PLOT1	- Flag to plot 3D trajectories	{ 0 to omit }
PLOT2	- Flag to plot missile characteristics	{ 1 to display }
XMAX, YMAX, ZMAX	- Scaling for 3D plots	
T2LIMIT	- Time limit for simulation	

To view the current value for a variable, enter the variable name at the MATRIXx shell prompt thus:

```
<> X0
```

```
X0 = 10000.
```

To modify the variable's value, enter <variable name> = <new value> thus:

```
<> X0 = 20000
```

```
X0 = 20000.
```

2.3 Simulation outputs

The simulation is capable of producing three different graphical displays. The first is a display of the missile launch angles which is shown at the beginning of the simulation, the other two displays are updated continually during the simulation. One of these displays shows three dimensional trajectories of the missile and the target and the other shows some of the characteristics of the missile during flight.

2.3.1 Launch angles

At the start of every simulation, a three dimensional representation of the missile with its base at the origin of a set of 3D axes aiming straight down the X axis is displayed. The missile figure is then elevated to the launch elevation angle and then rotated around to the launch bearing angle. The missile figure then moves off the screen in the direction it is heading. Figure 1 gives an example of what the screen may look like.

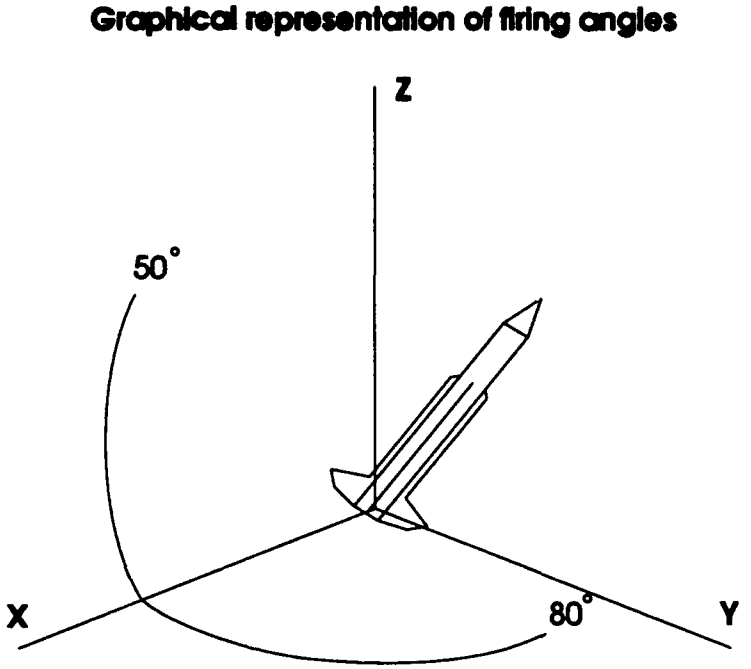

Figure 1. Display of firing angles

2.3.2 3D Trajectories

If the PLOT1 variable is set to 1, then during the simulation a three dimensional plot of the missile and target trajectories will be displayed (figure 2). The missile's trajectory is shown in blue and the target's trajectory is shown in red. The 3D effect is enhanced with the use of vertical droppers (lines drawn parallel to the Z axis from the position of the missile/target to the XY plane). The missile trajectory is further enhanced with the use of lines drawn from the "shadow" of the missile (the point directly below the missile) perpendicular to the X and Y axes respectively.

2.3.3 Missile characteristics

If the PLOT2 variable is set to 1, then during the simulation, a display of the missile's characteristics will be shown (figure 3). The display is split into three areas described below.

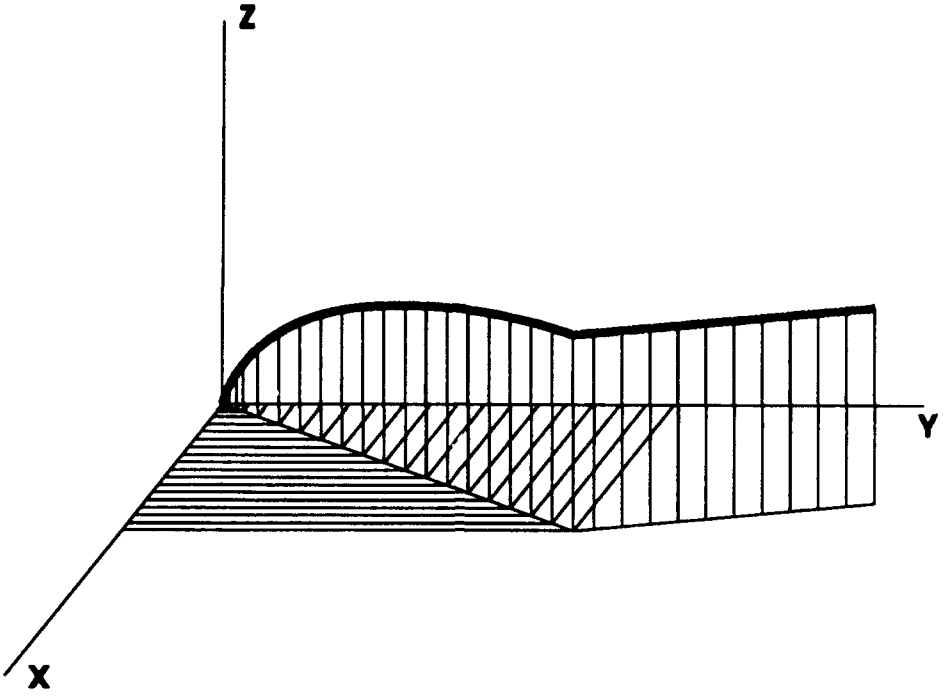

Figure 2. Display of 3D trajectories

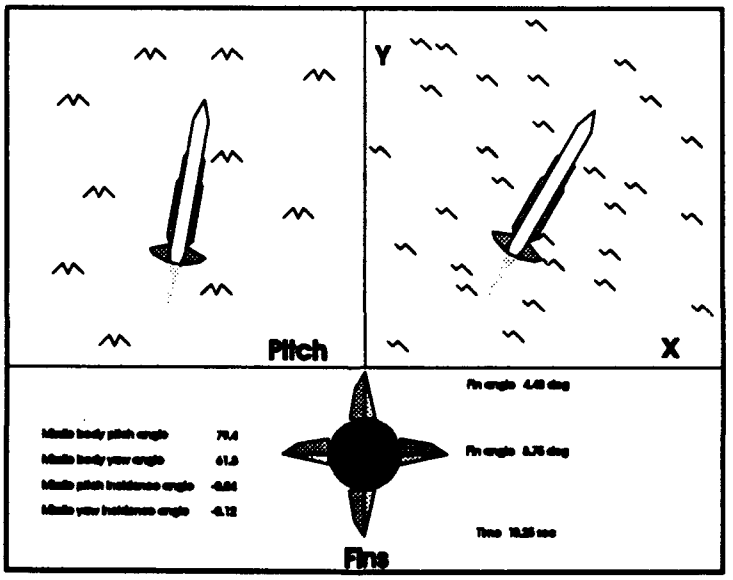

Figure 3. Display of missile's characteristics

The top left section shows the missile in the pitch plane. The figure of the missile is drawn at its current pitch angle on a background of bird figures. The background moves, at a speed relative to the current missile velocity in the pitch plane, in the opposite direction to the pitch angle of the missile's actual flight path. This attempts to give the effect of viewing the missile moving through the sky from the side. There is a flame drawn out the back of the missile where its length represents the current phase of the missile's flight, i.e. a full length flame represents the boost phase, a half length flame represents the sustain phase, and no flame for the glide phase.

The top right section of the display shows the missile in the yaw plane. The missile is drawn at its current yaw angle on a background of wave figures. This background moves, relative to the current missile velocity in the yaw plane, in the opposite direction to the yaw angle of the missile's actual flight path. This attempts to give the effect of viewing the missile from directly above. There is also a flame drawn out the back of the missile as described for the missile in the top left section of the display.

The bottom section of the screen shows the fin movements of the missile along with some numerical data for the top two sections. A rear view of the missile is displayed with the fins in the orientation specified by the ZRODG variable, (figure 3 shows the missile in the 0 degree orientation). The deflection of each pair of fins is displayed both graphically and numerically. The graphical representation of the fin shows the rear half of the fin with a kinked edge whereas the front half has a straight edge. The actual value of each fin deflection is displayed to the right of the corresponding fin. This bottom section also displays the following values :

a)Missile body pitch angle,

b)Missile body yaw angle,

c)Missile pitch incidence angle,

d)Missile yaw incidence angle,

e)Time.

2.4 Program termination conditions

The conditions to terminate the program consist of a number of warning conditions of a fatal nature. These are:

a) The run time limit.

b) Missile is no longer closing to target (effective after the boost-phase).

c) The sine of the missile pitch angle is greater than unity (almost vertical missile orientation).

d) The tangent of the missile roll angle exceeds 0.4 (fail to maintain zero roll objective).

e) The missile is below the ground level (ditched)

f) The missile incidence angle exceeds 30° (limit for the metod of finding stability derivatives).

g) The missile Mach number exceeds 7.0. (limit for calculations based on Mach number).

h) The missile static margin is negative (effective after the boost-phase).

i) The missile seeker head azimuth or elevation angle exceeds 60° (mechanical limit).

j) The missile roll rate exceeds 540 °/s (equations for yaw and pitch assume negligible roll rate).

k) The missile mass is negative.

l) The stagnation temperature is excessive for steel (missile is damaged).

m) The missile lateral acceleration in yaw and pitch plane exceeds 18g (structural damage limit).

n) The missile velocity is subsonic (missile is no longer has an effective capability to catch the target).

o) The closing speed is less than 550 f/s (168 m/s) (minimum dopler shift to achieve and maintain the front lock).

2.5 Program termination outputs

The program produces an output array, **Y(m,n)**, where **m** is the number of output variables (which is 191) and **n** is the number of time steps performed during the simulation. **Y** can be used to monitor the performance of the selected missile components during the simulation or to compare the simulation results with telmetry data which can be obtained from the actual missile firing. The first 20 variables of **Y** are defined below. Note that the definitions of the remaining variables are available in the actual program.

Y(1,n) = Closing velocity	(m/s)
Y(2,n) = Missile velocity	(m/s)
Y(3,n) = Missile x position in Earth Axes	(m)
Y(4,n) = Missile y position in Earth Axes	(m)
Y(5,n) = Missile z position in Earth Axes	(m)
Y(6,n) = Target x position in Earth Axes	(m)
Y(7,n) = Target y position in Earth Axes	(m)
Y(8,n) = Target z position in Earth Axes	(m)
Y(9,n) = Tangent of missile body yaw angle in Earth Axes	
Y(10,n) = Sine of missile body pitch angle in Earth Axes	

Y(11,n) = Missile to target range	(m)
Y(12,n) = Head Gimbal angle in A-plane	(rad)
Y(13,n) = Head Gimbal angle in B-plane	(rad)
Y(14,n) = Missile body total incidence angle	(rad)
Y(15,n) = Maximum missile lateral acceleration limit	(m/s^2)
Y(16,n) = Missile Mach Number	(M)
Y(17,n) = Achieved missile lateral acceleration in pitch	(m/s^2)
Y(18,n) = Achieved missile lateral acceleration in yaw	(m/s^2)
Y(19,n) = Total drag force coefficient	
Y(20,n) = Missile centre of gravity position from the nose.	(m)

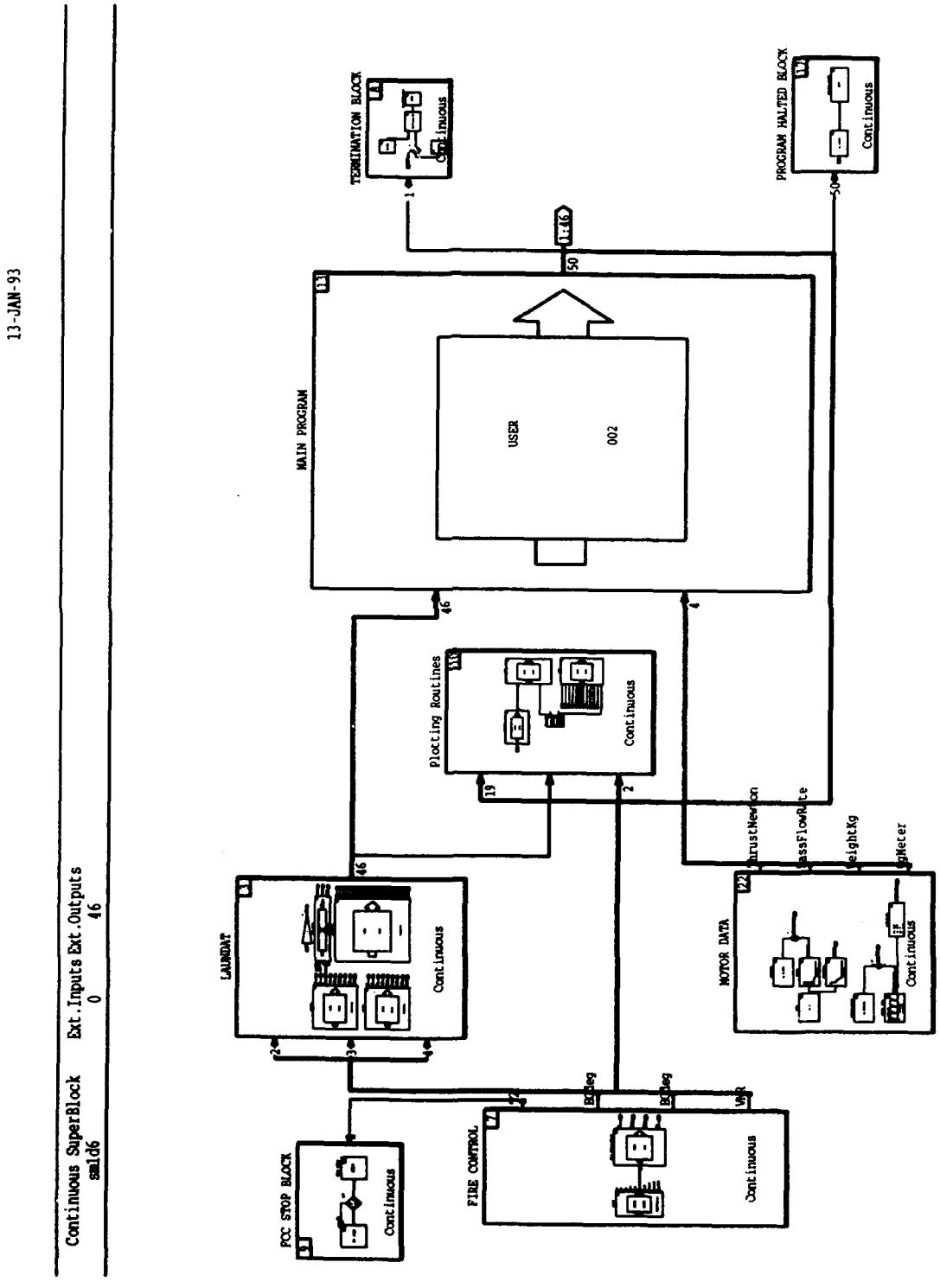

Figure 4.Main Block Structure of the Model (46 external outputs).

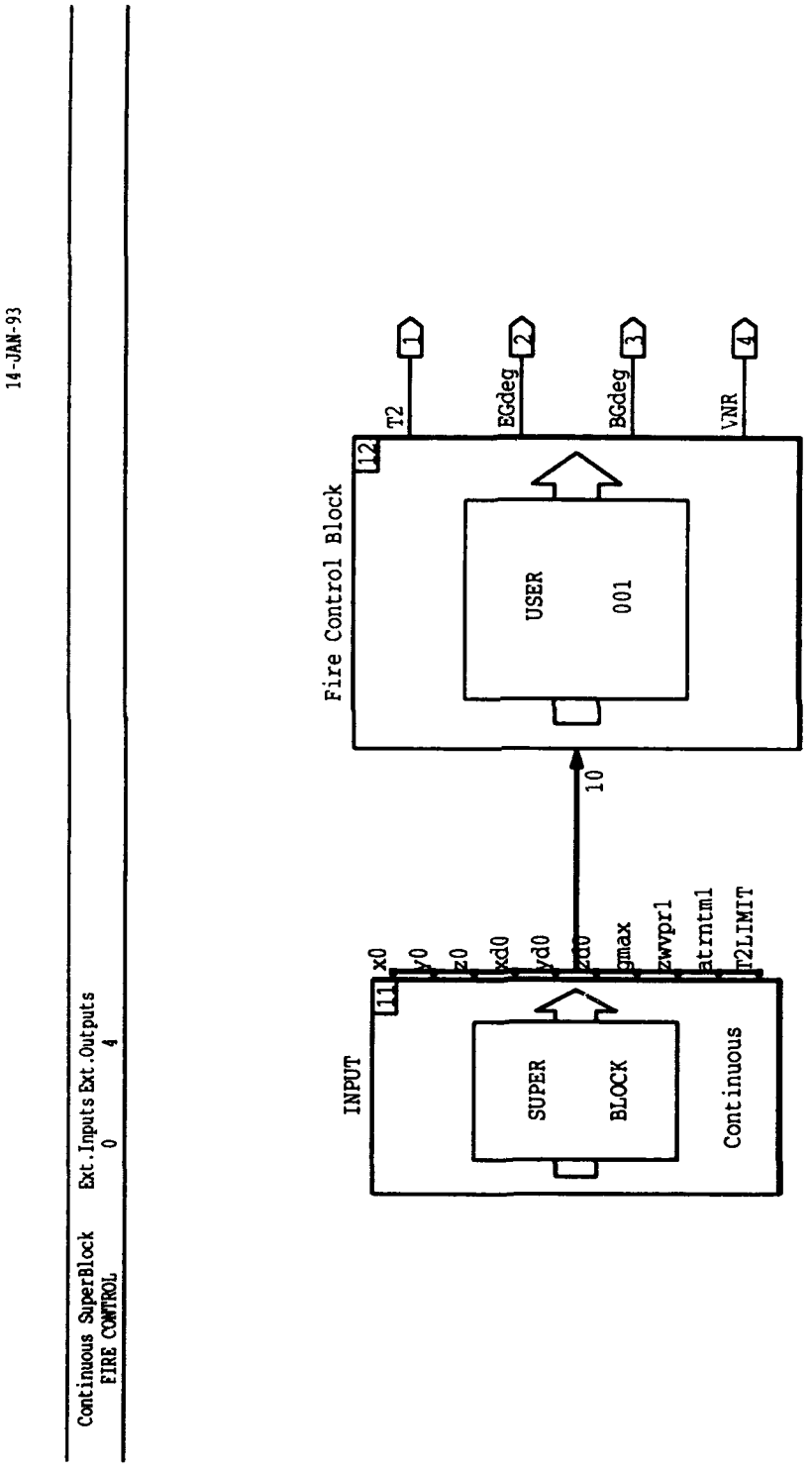

Figure 5. Fire Control Computer Block Diagrams.

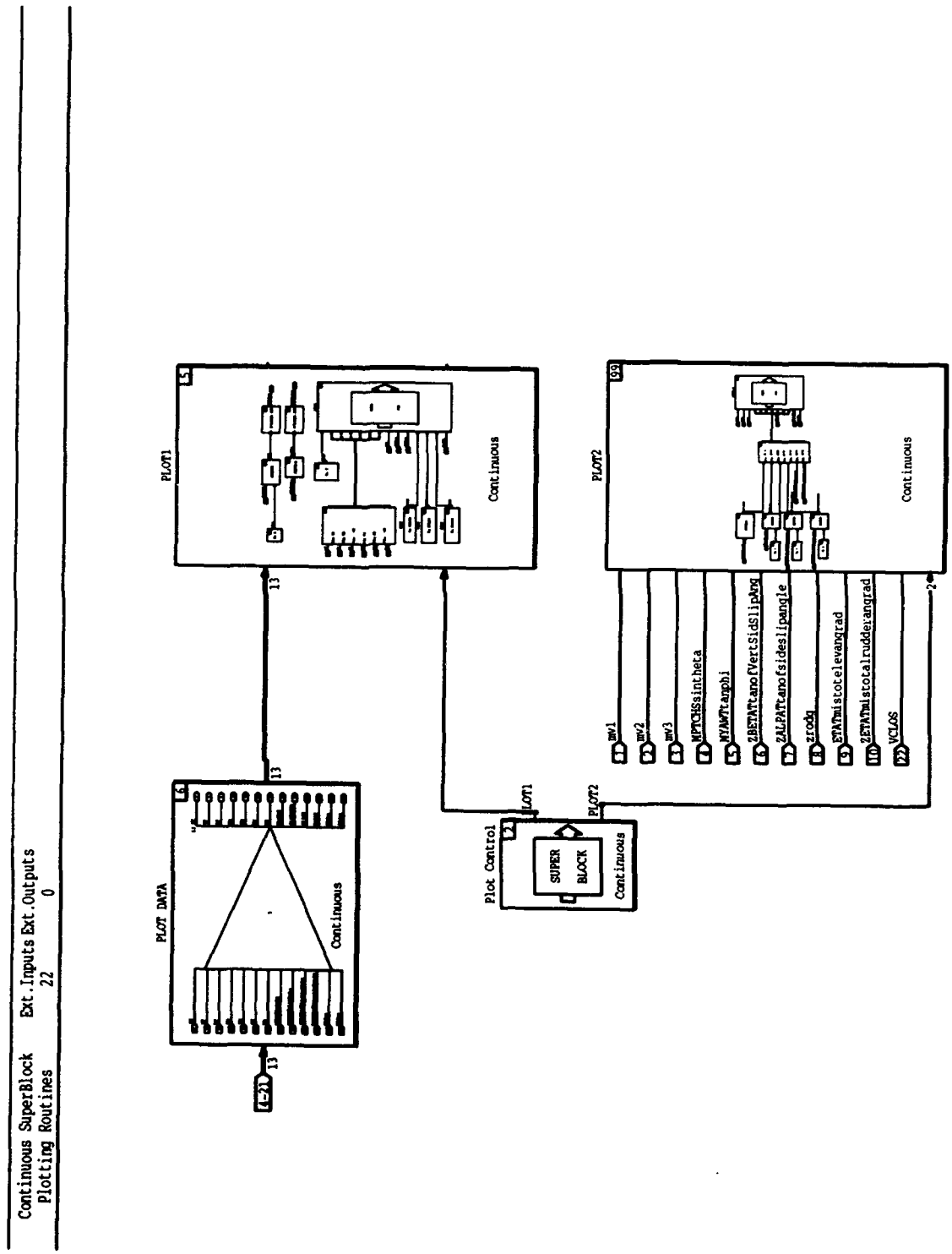

Figure 6. Graphical Output Block Diagrams.

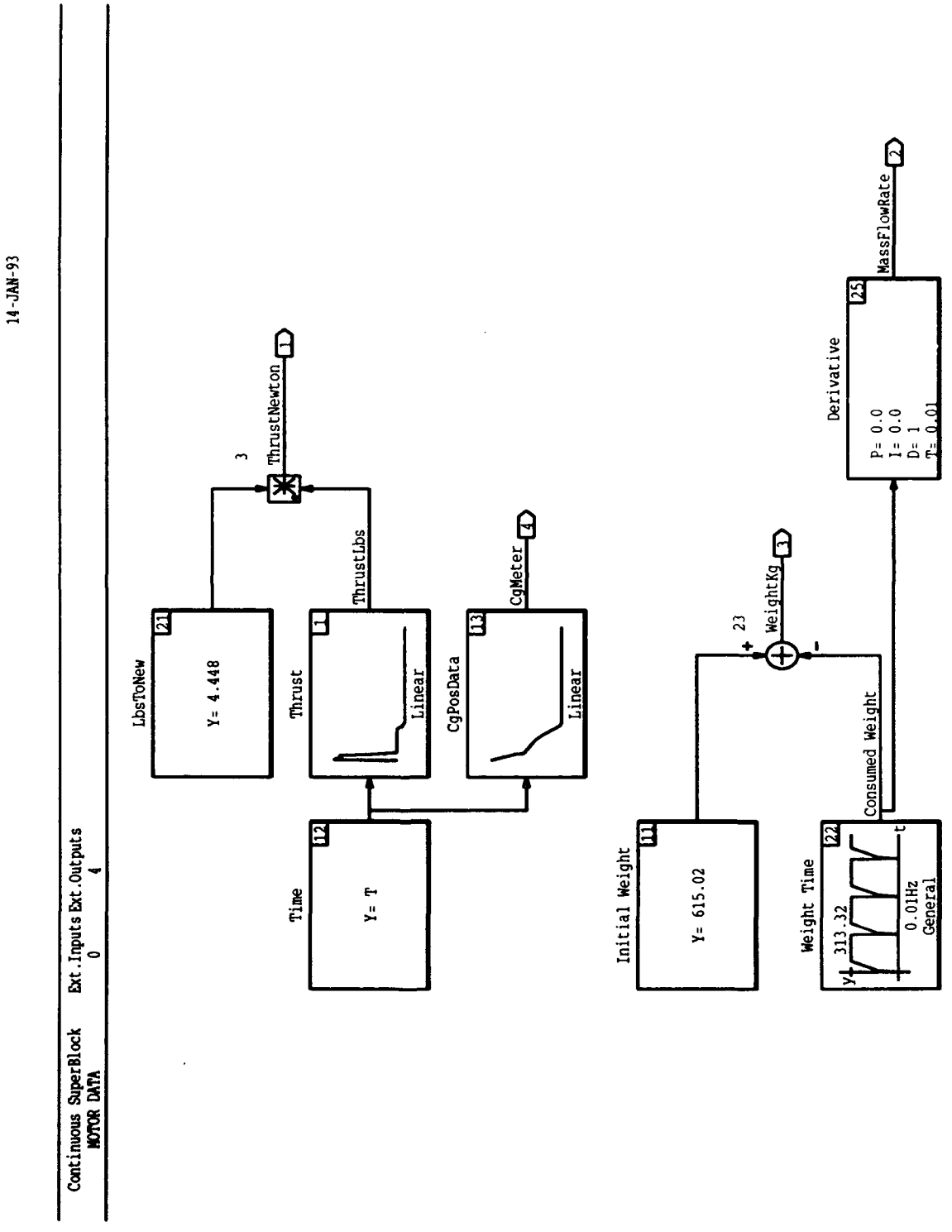

Figure 7. Missile Rocket Motor Data Blocks.

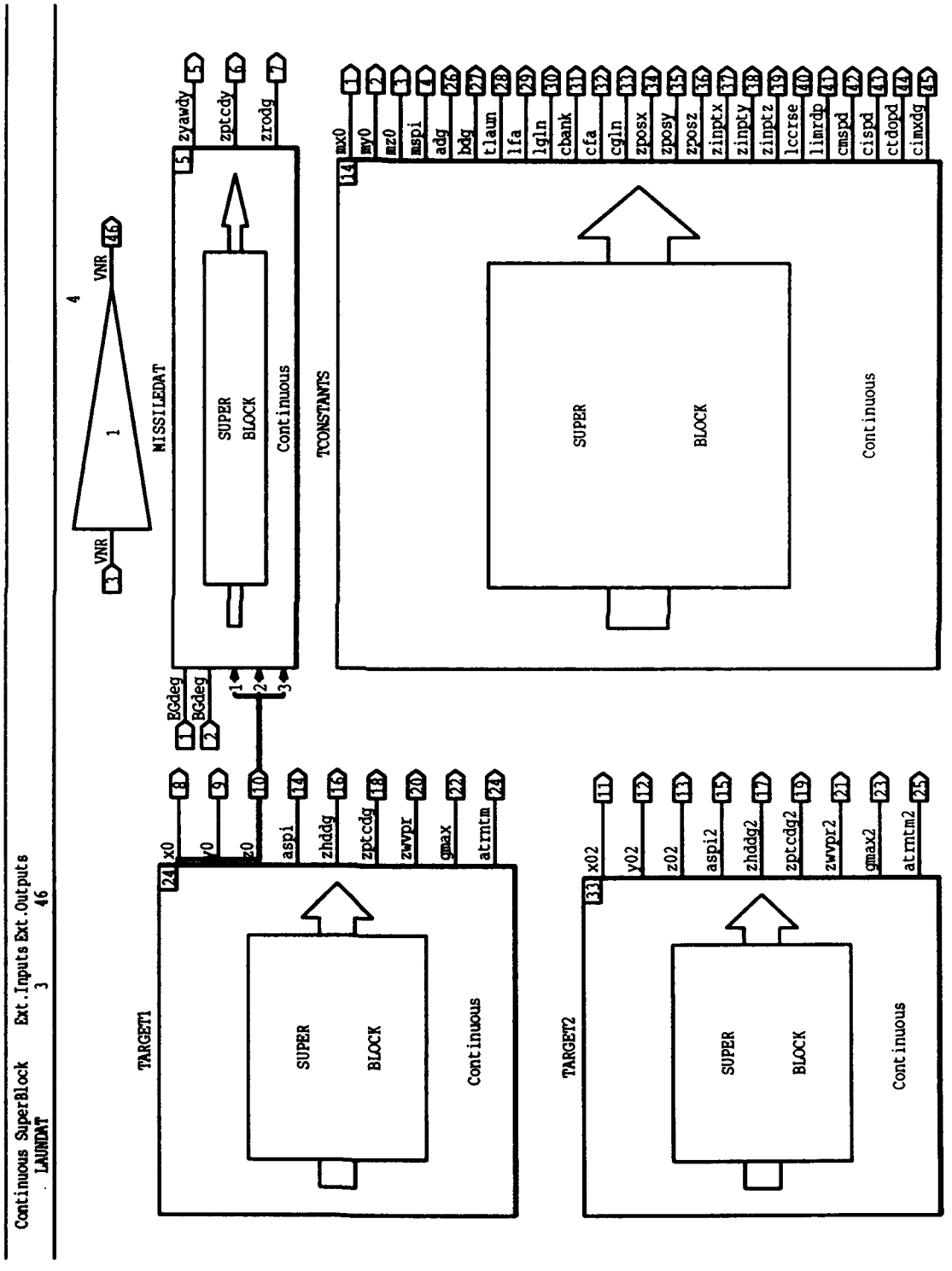

Figure 8. Launcher Data Blocks.

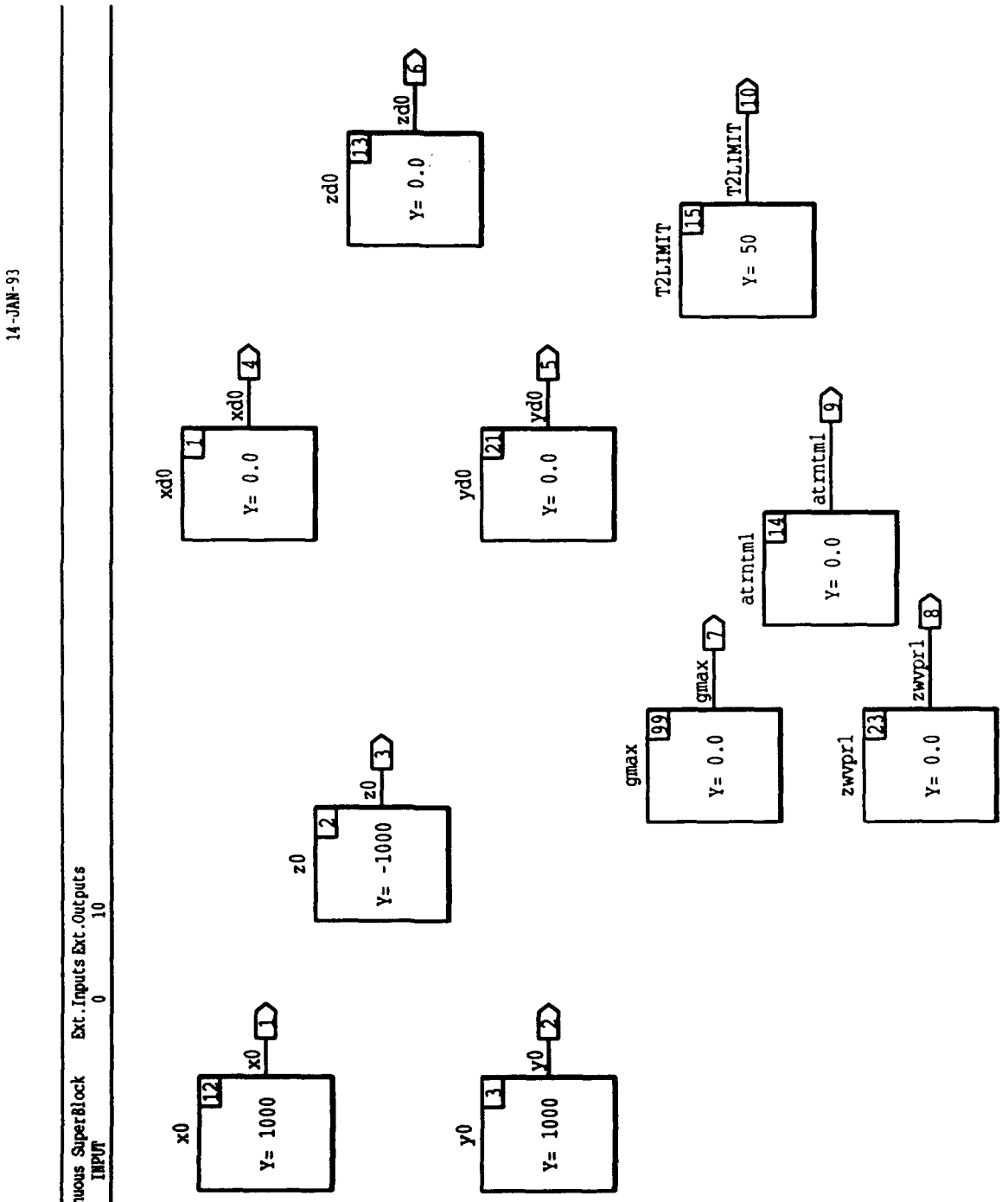

Figure 9. Target Information Block.

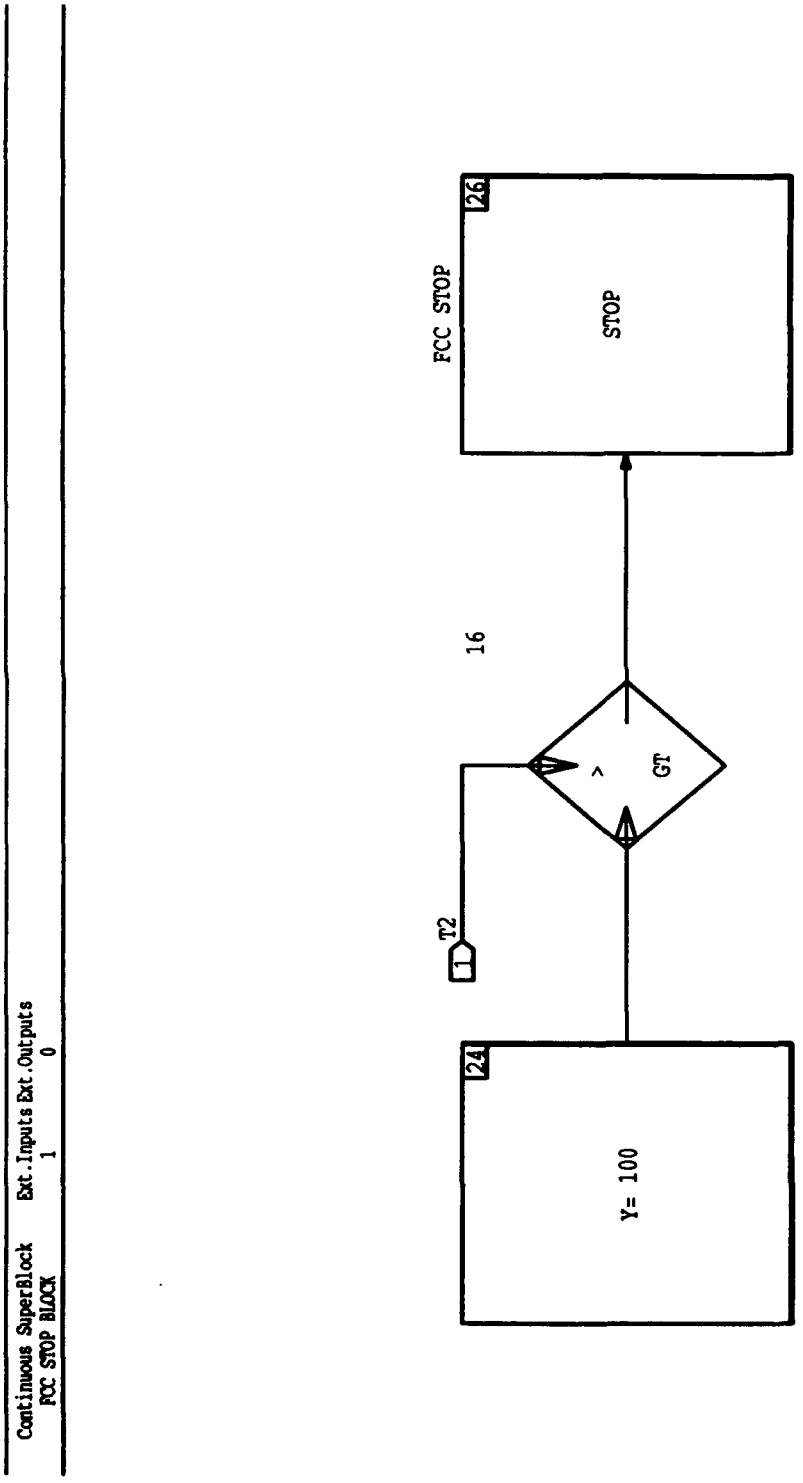

Figure 10. Fire Control Computer Stop Blocks.

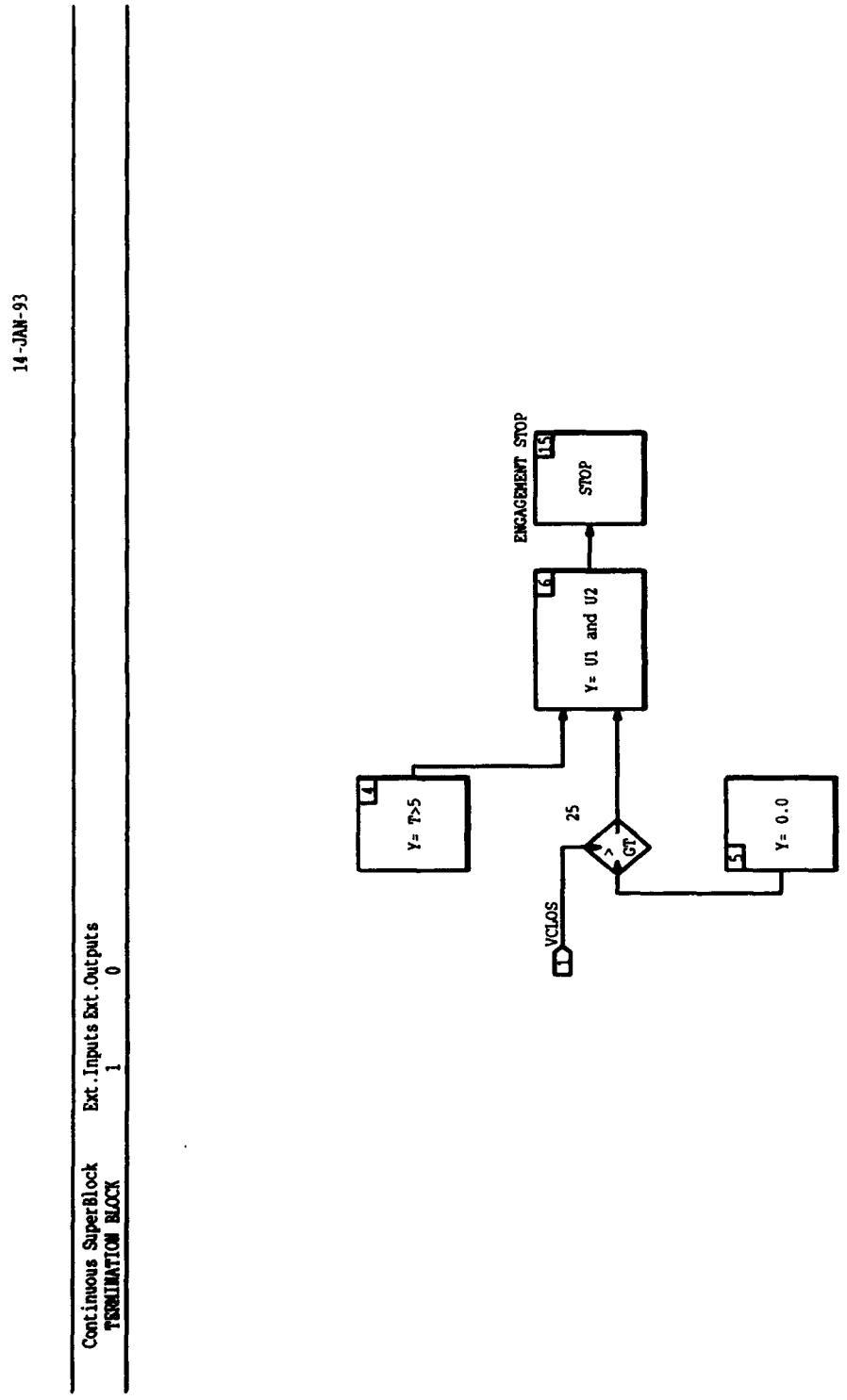

Figure 11. Program Termination Block.

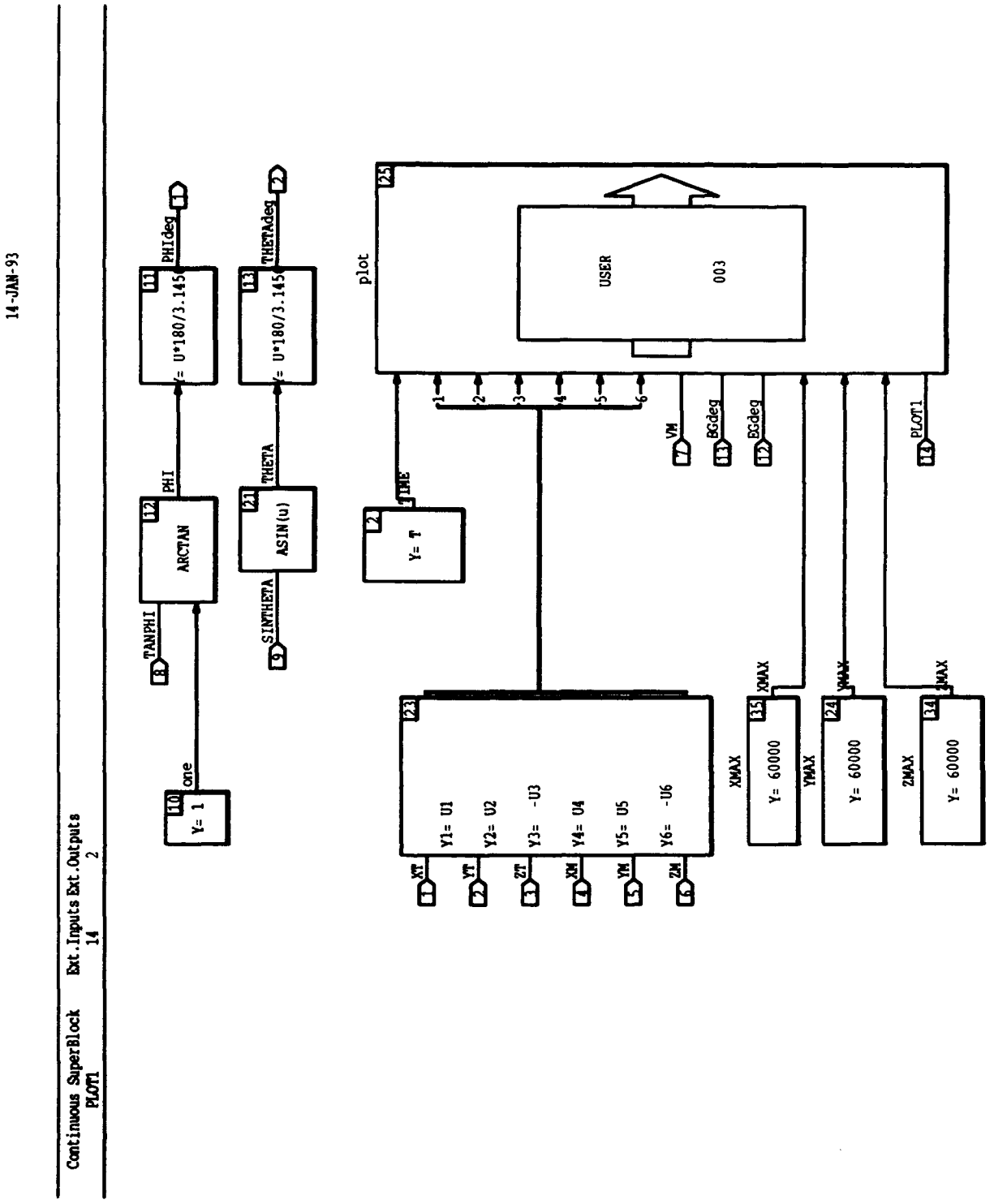

Figure 12. Graphical Output Block Diagrams (Option 1).

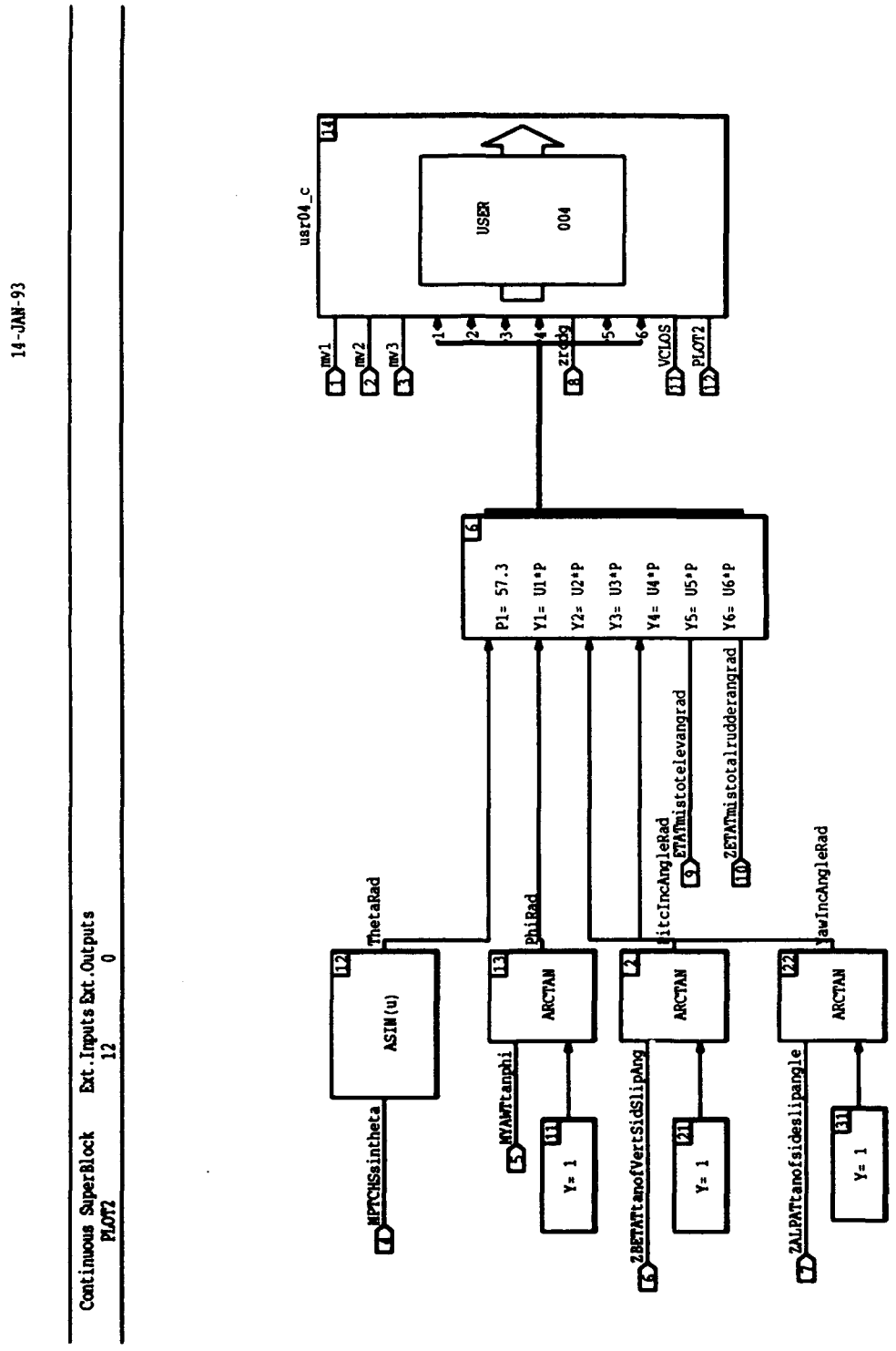

Figure 13. Graphical Output Block Diagrams (Option 2).

3. REFERENCES

1. G. IBAL "A Miss-Distance Model For Standard Missile 1, MR, Block 6" DSTO Technical Report, ARL-TR-011, February 1993.

DISTRIBUTION

AUSTRALIA

Department of Defence		COPY NO
Defence Central		
Chief Defence Scientist	)	
FAS, Science Policy	)shared copy	1
AS, Science Corporate Management	)	
Assistant Secretary, Scientific Analysis		2
Councellor, Defence Science, London(Doc Data sheet only)		
Councellor, Defence Science, Washington(Doc Data sheet only)		
Senior Defence Scientific Adviser		3
Scientific Adviser, POLCOM		4
Electronics Research Laboratory		
Director		5
Chief, Guided Weapons Division	)	
Research Leader, Guided Weapons	)shared copy	6
Research Leader, Seeker Technology	)	
Head, Guidance Control and Simulation		7
Head, Radio Frequency Seekers	)	
Head, Missile System Anaysis	)shared copy	8
Chief, Electronic Warfare Division	)	
Head, ECM	)shared copy	9
Mr F. Burden	)	
Author: Dr G. Ibal		10
Mr S.J. Retallick		11
Dr P.Simms		12
Dr D. Bucco		13
Dr D. Ciampa		14
Materials Research Laboratory		
Director/Library	)	
Chief, Maritime Ordinance Division	)shared copy	15
Dr M. Battaglia	)	
Navy Office		
Navy Scientific Adviser		16
Maritime Headquarters		
DNMOP		17
DRANRAU		18
HMAS WATSON		
DRANSWARS		19
Air Force Office		
Scientific Adviser, Air Force		20

Army Office	
Scientific Adviser, Army	21
HQ ADF	
Director General Force Development (sea)	22
Director Combat Force Development (sea)	23
Library and Information Services	
Defence Central Library - Technical Reports Centre	24
Manager Document Exchange Centre	25
Defence Research Information Centre UK	26-27
National Technical Information Service US	28-29
Director Scientific Information Services Canada	30
Ministry of Defence New Zealand	31
National Library of Australia	32
Library DSD	33
AGPS	34
Librarian H Block, Victoria Barracks Melb	Doc Control Sheet only
British Library Document Supply Centre	35
DSTOS Research Library	36-37
SPARES (6 COPIES)	38-43
TOTAL (43 COPIES)	

Department of Defence

DOCUMENT CONTROL DATA SHEET

Page Classification
UNCLASSIFIED
Privacy Marking/Caveat

1a. AR Number	1b. Establishment Number	2. Document Date	3. Task Number
AR-008-858	ERL-0817-GD	JANUARY, 1994	NAV 93/016 WA No. 408662

4. Title

USER MANUAL FOR STANDARD MISSILE-1, BLOCK VI, MISS-DISTANCE MODEL

5. Security Classification

Document	Title	Abstract
U	U	U

S (Secret) C (Confi) R (Rest) U (Unclass)

• For UNCLASSIFIED docs with a secondary distribution LIMITATION, use (L)

6. No. of Pages 18

7. No of Refs. 1

8. Authors

G. IBAL & S. RETALLICK

9. Downgrading/Delimiting Instructions

UNCLASSIFIED

10 a. Corporate Author and Address

Electronics Research Laboratory
PO box 1600
SALISBURY SA 5108

10 b. Task Sponsor

11. Officer/Position responsible for

Security N/A

Downgrading N/A

Approval for Release

12. Secondary Release of this Document

APPROVED FOR PUBLIC RELEASE

Any enquiries outside stated limitations should be referred through DSTIC, Defence Information Services, Department of Defence, Anzac Park West, Canberra, ACT 2600.

13 a. Deliberate Announcement

NO LIMITATIONS

13 b. Casual Announcement (for citation in other documents)

☑ No Limitation

☐ Ref. by author & Doc No only

14. DEFTEST Descriptors

MISSILES
MODELLING
MISS DISTANCE
COMPUTER PROGRAMS

15. DISCAT Subject Codes

16
1205

16. Abstract

A MISS-DISTANCE MODEL OF STANDARD MISSILE-1, BLOCK VI, IS DEVELOPED WITHIN THE MATRIXx/SYSTEMBUILD PACKAGE ON A SUN SPARCSTATION. THIS DOCUMENT IS INTENDED TO BE A USER MANUAL FOR EXECUTING THE PRESENT MATHEMATICAL MODEL.

Page Classification
UNCLASSIFIED
Privacy Marking/Caveat

16. Abstract (CONT.)		

17. Imprint

Electronics Research Laboratory
PO Box 1600
SALISBURY SA 5108

18. Document Series and Number	19. Cost Code	20. Type of Report and Period Covered
ERL-0817-GD		

21. Computer Programs Used

FORTRAN, WORD PERFECT, MATRIXx

22. Established File Reference(s)

23. Additional information (if required)